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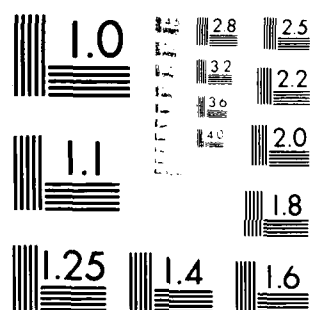   FORT BELVOIR VA R L ROSENTHAL ET AL. 1983 ETL-R050
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The application of computer technology to cartography has produced numerous digital techniques that are employed in a wide variety of independent automated and semi-automated cartographic systems. These systems are used by government agencies and private industry for compiling maps and charts. The US Army Engineer Topographic Laboratories (USAETL) is testing and evaluating a subset of available off-the-shelf and state-of-the-art R&D digital techniques in an Experimental Geo-Cartographic Laboratory System and developing a methodology for automated map and chart production. The methodology, which is based upon geographic and cartographic

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A METHODOLOGY FOR DIGITAL PROCESSING OF GEOGRAPHIC AND CARTOGRAPHIC DATA

Mr. Richard L. Rosenthal, Cartographer

Mr. William Opalski, Physical Scientist
Mr. Douglas Caldwell, Cartographer
United States Army Engineer Topographic Laboratories
Fort Belvoir, Virginia 22060
(703) 664-3722

Dr. Carl Reed
Autometric, Incorporated

BIOGRAPHICAL SKETCH

Richard Rosenthal is a cartographer specializing in automated and digital techniques. He received a BA in Geography in 1976 from Boston University and a MS in Cartography from the University of Wisconsin-Madison in 1982. He has been employed at the US Army Engineer Topographic Laboratories since 1978. His research interests center on automated techniques for cartographic image display.

ABSTRACT

The application of computer technology to cartography has produced numerous digital techniques that are employed in a wide variety of independent automated and semi-automated cartographic systems. These systems are used by government agencies and private industry for compiling maps and charts. The U.S. Army Engineer Topographic Laboratories (USAETL) is testing and evaluating a subset of available off-the-shelf and state-of-the-art R&D digital techniques in an Experimental Geo-Cartographic Laboratory System and developing a methodology for automated map and chart production. The methodology, which is based upon geographic and cartographic principles, is defined and outlined in this paper along with early experimental results derived from the integration of key hardware/software systems.

INTRODUCTION

The methodology developed for automated map and chart production at USAETL is based in part on interfacing state-of-the-art stand-alone automated cartographic systems resident in the Labs. The experimental geo-cartographic system resulting from this linking of systems is designed

to include input, manipulation, and output processors. Valid cartographic data derived in the system "flows" through the system in an all digital mode and may be output to a device such as the large-format laser platemaker. The basic assumption underlying the methodology is that there exists a fundamental difference between geographic and cartographic data processing. Digital geographic processing is defined as those operations which involve the manipulation of locational data and its associated attribute identifiers. Included are the basic digital geographic processing operations of data capture, data manipulation, and data retrieval. Locational data is expressed in geographic coordinates, typically latitude and longitude. In contrast, digital cartographic processing is defined as those operations which involve the graphic expression, by maps and charts, of physical features on the earth's surface. Graphic expression may be presented in both hard-copy and soft-copy graphic (image) displays. Graphic displays use table coordinates or device coordinates as input.

LABORATORY ENVIRONMENT

The Experimental Geo-Cartographic Laboratory System methodology has been developed by integrating existing digital geographic and cartographic systems. Geographic data processing is addressed by the Analytical Mapping System (AMS) from which geographic data is passed to the cartographic systems for symbolization, editing, and plotting. The Intergraph System and the Scitex System provide editing and symbolization capabilities. They may be used to prepare edited cartographic data for image forming systems such as the Gerber/CRT Print Head, the Large-Format Laser Platemaker, and the Scitex Plotter. The Scitex is resident at the Defense Mapping Agency.

The Analytical Mapping System (AMS)

The Analytical Mapping System (AMS) forms the digital geographic processing system. AMS uses spatial data structures in order to maintain the topological validity of the geographic data. Additionally, AMS incorporates procedures for geographic data input, data manipulation, and data retrieval. Unlike graphics systems which treat geographic data like an engineering drawing, AMS is designed to treat geographic data in a rigorous manner. During geographic data capture, AMS considers the nature of the input sources (maps and photos) and removes the bias introduced by projections and transformations. The common problems of paneling and edge matching are not found in AMS as all data is stored in common geographic coordinates. Hardware tools for geographic data input include a digitizing tablet and an APPS-IV analytical plotter. The

APPS-IV supports digital graphics superimpositioning.

AMS is considered state-of-the-art because it brings the advanced concepts of topological validity and spatial data structures into the process of digital map and chart production.

The Intergraph System

An Intergraph interactive graphic display and edit system forms the cartographic processing system. The Intergraph permits multiple simultaneous displays of graphic data with the ability to fully interact with the data using a digitizing tablet and menu. Cartographic data stored in geographic coordinates in AMS is converted to table coordinates and transferred to the design file of the Intergraph for symbolization and cartographic expression. The system has the basic tools for creating a symbol library. Data is displayed as color separate sheet overlays with a view toward editing symbol placement and design. A geographic names overlay is included in the compilation. Output processors format the cartographic data for input to raster and vector plotters such as the large-format laser platemaker, the CRT printhead, and several standard plotters and display devices.

The Intergraph system is important in the experimental system because it enables the cartographer to employ state-of-the-art interactive edit technology as well as polygon processing to output terrain analysis displays and graphics.

Scitex Scanner/Plotter

The Scitex pre-lithographic edit system is used in the production of nautical charts at the Defense Mapping Agency. The Scitex system digitizes maps as raster data, edits them by a combination of raster and vector techniques, and exposes the edited data on large-format press-ready films. Besides functioning as a comprehensive system for producing and updating cartographic material, the Scitex can also use digital data from other sources. Input of other digital data sets is possible using the Standard Interchange Format (SIF).

Gerber/CRT Printhead

Automation of the processes of generation and placement of map names and symbols is available on the CRT Print Head System. The system consists of a precision CRT mounted on a precision flatbed plotter, stroke and character generators to control the CRT operations, and a digital

computer to direct and control the system. In operation, a large sheet of photographic film is mounted on the plotting table, a data tape is read into the system, and the geographic names and cartographic symbols are written onto the CRT display which exposes a photographic emulsion to produce a film image. The CRT Print Head System produces type and symbols having a wide variety of point sizes and line weights and significantly increases the speed by which color separates are produced in the Defense Mapping Agency production centers.

Large-Format Laser Platemaker

The Large-format Laser Printing-Plate Maker (LPM) is an example of a specialized scan-line raster display which uses a constant size binary pixel. The LPM reads digital data from magnetic tape and employs an electro-mechanical means of aiming and modulating laser-generated ultraviolet light to expose binary raster images on photosensitive media. The LPM was developed for use in preparing four foot by five foot plates of maps and charts for accurate printing. However, the device is transparent to image content and can be used in any computer-to-plate or computer-to-film application where large format and high accuracy are important requirements. The active image area on the LPM is 42 by 59 inches. An LPM image is generated with up to 2.6 billion binary pixels based on a 25 micron distance between pixels with a total of 42,672 pixels in the X direction and 59,944 pixels in the Y direction.

EXPERIMENTAL GEO-CARTOGRAPHIC ISSUES

Work efforts have begun in the laboratory to translate the geographic/cartographic data processing methodology into an operational experimental system. The purpose is to understand and solve the problems that occur when attempting to digitize and transfer data from one "independent" system to another. Problems such as vector-to-raster conversion to permit output to the laser platemaker, and translation between symbol libraries, such as from the Intergraph to the CRT printhead font library, are being addressed. Several interfaces and automated cartographic functions are under development.

Batch Data Entry

Routines presently being tested permit batch entry into AMS of digital geographic data currently in the DMA inventory and digital geographic data collected by existing DMA hardware/software systems. Batch data entry of existing digital geographic data with associated attributes has been demonstrated with DMA Digital Landmass Simulation (DLMS)

Digital Feature Analysis Data (DFAD). Additional
capabilities are being designed to permit batch input of
digital data from DMA's proposed Standard Lineal Format
(SLF), the Automatic Graphic Digitizing System (AGDS), and
Intergraph/Scitex Standard Interchange Format (SIF).

AMS to Intergraph Interface

The Analytical Mapping System generates basic point, line,
and area data with associated attributes using one of many
available map transformations. The resultant digital
cartographic data is output to magnetic tape which is
processed on the Intergraph system by the AMS/Intergraph
interface software. The interface software consists of a
single module that reformats point, line, and area
coordinates that are in AMS Export format into an internal
Intergraph format. The Intergraph Interactive Graphics
Display System (IGDS) offers software callable subroutines
that allow an application program to convert data to the
IGDS proprietary internal data structures and build a
hierarchical data base containing associated feature
attributes.

Automated Cartographic Map Image and Symbol Formation

The Intergraph interactive display and edit system is being
used as a test bed to evaluate the feasibility of
implementing a digital symbol library based on the Defense
Mapping Agency (DMA) Product Specificatons for 1:50,000
Scale Topographic Maps of Foreign Areas. The process of
using Intergraphs basic edit and symbol generation routines
is under study. Complex symbols such as dual case road
intersections and variable shaped bridges will require
development of a sophisticated set of edit instructions
which can be initiated with a single command. In some
cases a series of menu commands will be designed so that a
cartographer can construct variable dimensioned symbols
while performing map edit/compilation on the Intergraph.

Full symbolization is currently possible using automated
symbolization routines which convert rudimentary digital
representations of point, line, and area features into a
finished cartographic form. Examples include the
conversion of centerline road data to dual-cased graphic
form; the conversion of point locations and identifiers to
appropriate point symbols; and the application of fill
patterns to tagged areal features. The automated
symbolization normally performed at this point is limited
to graphic conversions which generate vector
representations of cartographic symbols. Digital vector
representations can be applied to all cartographic symbols
except continuous tone and constant tone area tints.

Symbolization of continuous tone and constant tone area
tints has been demonstrated using the map image modifying
process known as digital halftoning. In manual and
computer-assisted map production methodologies, halftone
and tint screens are applied to a map image forming medium
using open-window negatives and mechanical registration
systems to control image position. In the automated
processing methodology, area fill algorithms apply digital
halftones and tint screens using the digital
representations of area features to control image position.
Registration of digital graphic images, including raster
representations of points, lines, areas, and halftone
screens, is provided by the computer and is maintained
within the resolution and accuracy of the output plotter.

The process of symbolization is applied to standard
topographic charts and terrain analysis overlays (thematic
maps) which are compiled using Intergraph's polygon
processor. This processor is a basic capability of the
Intergraph.

Automated Map Image Output

The Scitex and Laser Platemaker are two high-resolution
raster plotters which are available for output of fully
symbolized cartographic images. The Scitex is accessed
using the Standard Interchange Format (SIF) for
photoplotter emulation. The Scitex converts SIF data into
raster format for plotting. Raster data for output on the
Laser Platemaker is derived from vector data generated
using Calcomp compatible graphics routines. Images
generated for output on the Scitex and the Laser Platemaker
contain raster representations of point, line, and area
symbols including halftone screens.

The Gerber/CRT Print Head is also available for output of
symbolized cartographic images. The requirement for a CRT
Print Head symbol library and a translation table to
interface the Intergraph symbol library is under
investigation. The CRT Print Head can currently print
Intergraph symbols using Calcomp compatible routines.

Line Generalization and Feature Displacement

While full symbolization has been demonstrated and is
currently possible, modification of the symbolized data is
necessary to produce quality map products. Tasks which
have traditionally fallen under the realm of "cartographic
license" are required. These include such generalization
tasks as selection, simplification, and displacement. ETL
is investigating the manual generalization process at DMA
and reviewing state-of-the-art digital techniques. Based
on this study, research and development software can be

developed to evaluate the promising algorithms needed for fully automated cartographic processing.

CONCLUSION

The Experimental Geo-Cartographic Laboratory System provides a test-bed for developing a unified geographic and cartographic methodology. Existing systems for geographic data collection and manipulation, cartographic symbolization and editing, and automated map image output have been identified and initially integrated. The integration of these systems has raised a number pressing issues concerning a digital flow: issues of data reformatting, cartographic symbolization, and the digital definition of "cartographic license". ETL researchers are addressing these issues to bring an all digital geographic and multi-product cartographic production system closer to reality.

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